NOVEMBER/DECEMBER 2007

Zoogoer

VOLUME 36, NUMBER 6

REFRESHING
S H A R E

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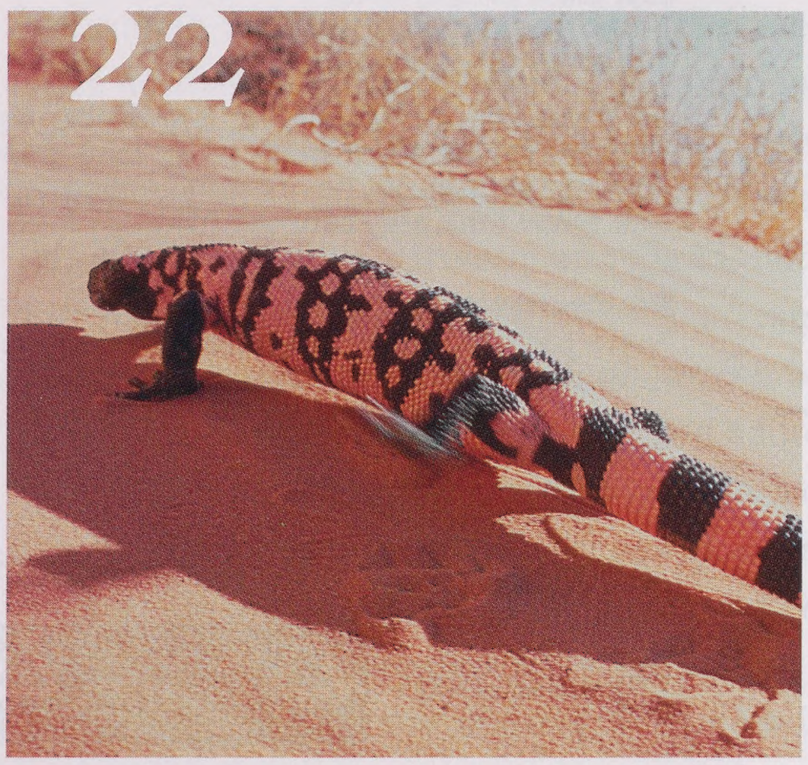

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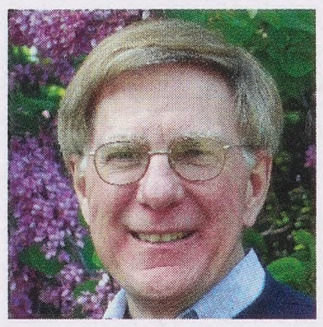


This winter will be brighter than ever at the Smithsonian's National Zoo! For the first time, FONZ and the Zoo are hosting a winter celebration illuminated by larger-than-life animals sculpted of colorful lights. And not just any lights, but environmentally friendly LED lights, a demonstration of our commitment to the sustainable use of natural resources. LED lights use about 90 percent less energy than traditional incandescent bulbs and last more than 130 times longer. Powered by Pepco, lead sponsor of the 25-night extravaganza, ZooLights promises to be the most brilliant winter festival in the area—and all for a great cause! Proceeds from ZooLights will help support the Zoo's conservation programs.

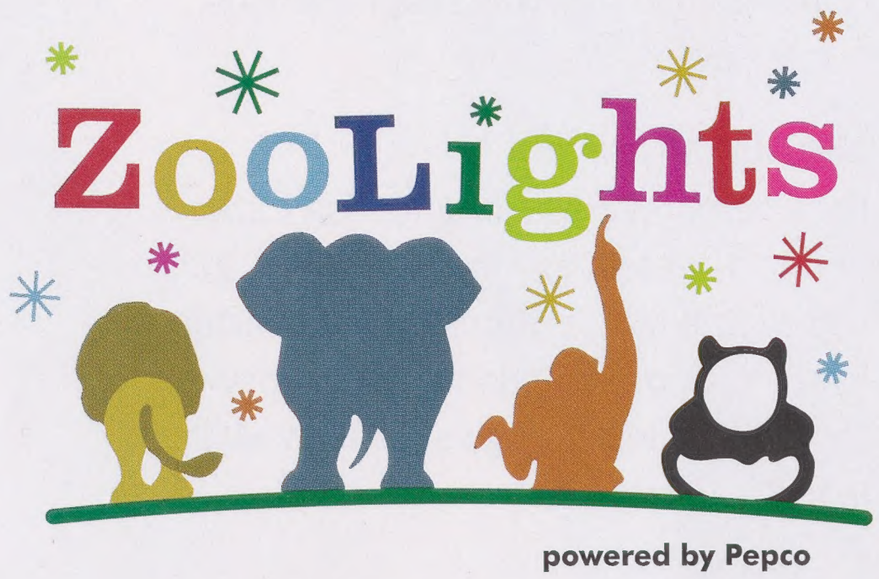
Featuring such favorites as lions, giant pandas, Asian elephants, Komodo dragons, and golden lion tamarins, the nearly 50 animal light sculptures will be arrayed along Olmsted Walk between the Small Mammal House and Lion/Tiger Hill at the Rock Creek end of the Zoo. The glowing animals will be more than just a light menagerie, though. We have selected species to display that are the focus of the Zoo's diverse conservation programs. So, as you stroll through the Zoo at night, admiring the artistry of the sculptures, you can also learn about the animals, what the Zoo is doing to save them, and how you can help—for instance, by emulating in your own winter decorations our use of LED lights. You will also learn about how the Zoo cares for animals during the winter, and how animals cope with the cold.

ZooLights will feature a variety of other activities, as well. Encounters with live animals, Zoo keepers, strolling singers, storytellers, and ice carvers will all be part of the festivities. Kids will enjoy making crafts, and everyone will delight in sipping hot chocolate, roasting marshmallows over a warming fire, and having a photo taken in front of a giant snow globe.

You can even get your holiday shopping done at the Zoo Store, which offers an assortment of unique wildlife-themed gifts, with something sure to please everyone on your list. And while you're thinking about presents for family and friends, don't forget Zoo animals. Look for a large Giving Tree decorated with suggestions for donating toys and other items to enrich the lives of the Zoo's animals.

ZooLights runs Wednesday through Sunday nights, 6 to 8:30 p.m., from November 28 to December 30. Tickets go on sale on November 1, and are $10 per person, per night, or just $6 for FONZ members. You can purchase your tickets online at **www.fonz.org/zoolights.htm**.

I hope to see you at ZooLights. I promise you an entertaining, enthralling, and enlightening winter evening at your National Zoo.



Sincerely,

Bob Lamb

Bob Lamb
Executive Director, Friends of the National Zoo

FONZ Friends of the National Zoo is the dedicated partner of the Smithsonian's National Zoological Park. FONZ provides exciting and enriching experiences to connect people with wildlife. Together with the Zoo, FONZ is building a society committed to restoring an endangered natural world. Formed in 1958, FONZ was one of the first conservation organizations in the nation's capital.

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Smithsonian **National Zoological Park** is located at 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537. Weather permitting, the Zoo is open every day except December 25. For hours and other information on visiting the Zoo, go to **www.fonz.org**.

Membership in FONZ offers many benefits: programs, publications, discounts on shopping and events, free parking, and invitations to special programs and activities to make zoogoing more enjoyable and educational. To join, write FONZ Membership, FONZ, P.O. Box 37012 MRC 5516, Washington, D.C., 20013-7012, call 202.633.3034, or go to www.fonz.org/join.htm.

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An audio version of *ZooGoer* is available on our website, for members who cannot read standard print due to disability. For more information, please visit **www.fonz.org/zoogoer.htm.**

On the cover: Giant anteater (*Myrmecophaga tridactyla*) Aurora, born July 24, rides on the back of her mother at the Smithsonian's National Zoo. Photo by Mehgan Murphy/NZP.

ASSOCIATION OF ZOOS & AQUARIUMS

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Accomplishments and Accreditation

As 2007 races to a close, our exciting new ZooLights winter celebration is the culmination of a very eventful year at the Smithsonian's National Zoo. Like ZooLights, many of our accomplishments in 2007 are highly visible.

Giant panda Mei Xiang did not bless us with another cub, but our colleagues in China agreed to let us keep cub Tai Shan until 2010—great news that was reported around the world. We were also delighted when a giant anteater was born, a first for the Zoo, and with the hatchings, also firsts, of a wattled crane and a white-naped crane.

Our new Cheetah Science Facility opened at the Zoo's Conservation and Research Center (CRC) in early October, and plans to upgrade the Cheetah Conservation Station at the Zoo are in place. Other exhibit improvements in the works include those for Amazonia, Think Tank, and Seals and Sea Lions.

Work began on Elephant Trails, our wonderful new Asian elephant exhibit slated for completion in 2011, and our research on these endangered animals continued to provide insights into how to conserve them in zoos and in the wild.

On another conservation front, Zoo scientists documented large-scale declines in a diverse array of common North American bird species—but we also expanded our Neighborhood Nestwatch program, which enlists members of the public to help scientists better understand what such common birds need to survive.

Less visible is that we're on schedule in the approval process for our facilities master plan, which will guide the Zoo's development, at Rock Creek in D.C., and at CRC in Front Royal, Virginia, over the next ten years. And, behind the scenes, our staff, enhanced in 2007 by the appointment of the first Fujifilm Curatorial Resident, are advancing the science of animal care every day.

A major effort was also launched this year to prepare for Association of Zoos and Aquariums (AZA) accreditation in 2008. AZA accreditation means official recognition and approval of a zoo or aquarium, and is based on an exhaustive evaluation by 12 animal and zoo experts who form the Accreditation Commission. The National Zoo is currently accredited, but the AZA requires that zoos be newly accredited every five years. This ensures that zoos meet or exceed AZA standards, which are constantly being raised to incorporate new knowledge and address new challenges.

The AZA standards are exacting, as is the accreditation process. The AZA's *Accreditation Standards and Related Policies* is 50 pages long; its *Guide to Accreditation of Zoological Parks and Aquariums* is nearly 40 pages. The detailed accreditation questionnaire runs about 20 pages, while our answers to the questions and supporting documentation will cover many hundreds of pages. The process includes a thorough site inspection and subsequent report by a subset of the experts on the Accreditation Commission that lasts several days. Then, finally, the entire commission reviews all of the material, sometimes asks for additional information, and interviews the zoo director face to face before deciding to accredit. For the Zoo, this last step will occur in September of next year.

The standards by which zoos are judged cover every aspect of operating a modern zoo, from animal husbandry and veterinary care to conservation, science, exhibition, and education programs, and from staff levels and credentials and visitor services to security and financial strength. The AZA believes that ensuring the highest standards of animal care in its member zoos is of utmost importance, and the accreditation process reflects that. In fact, of about 2,400 "animal exhibitors" licensed by the U.S. Department of Agriculture, fewer than ten percent earn AZA accreditation!

Our goal is to make the Smithsonian's National Zoo the finest zoo in the world—one that is setting and raising standards rather than merely meeting them, far less coming up short. So I view the accreditation process, arduous as it might be, as an important tool to help us achieve this challenging goal. It is an opportunity for us to put everything we do under a microscope, and then learn how we look when other experts do the same. I believe we are the finest zoo in some areas—our science, for instance, is unparalleled—and with Elephant Trails we will raise the bar on caring for Asian elephants. I also believe we know what it will take to reach that same level of excellence in everything we do. The accreditation process will tell us if we're on the right track.

If we are accredited, as I trust we will be, it will be thanks in large measure to the consistently generous support of FONZ members and many other Zoo and animal lovers in our community and across the nation. We simply couldn't do it without your help!

Sincerely,

John Berry

John Berry
Director, Smithsonian's National Zoological Park

Jessie Cohen/NZP

Giant anteater Aurora, the first of her species ever born at the Smithsonian's National Zoo, clings to her mother, Maripi. Juvenile giant anteaters may ride on the backs of their mothers until they are around one year old.

Animal News

A keeper at the Smithsonian's National Zoo looked in on female **giant anteater** (*Myrmecophaga tridactyla*) Maripi on the morning of July 24 and noticed a wonderful surprise—a tiny baby clinging to Maripi's chest! It was the first giant anteater ever born at the Zoo. Staff had known for months that Maripi had mated with the Zoo's male giant anteater, Dante, and was pregnant, but had expected her to give birth in August rather than July.

Zoo veterinarians did not examine the newborn for the first few weeks of its life so as not to disturb the first-time mother, which like all female giant anteaters raises her young without help from the male. During that time the baby became something of a celebrity when the public was invited to vote on its name. Zoo veterinarians examined it on September 5 and determined that it is female; that same day, the winning name, "Aurora," was announced. You can see Maripi, Aurora, and Dante at their exhibit near Lemur Island.

On September 21, eight-year-old male **cheetah** (*Acinonyx jubatus*) Ume was euthanized after experiencing significant decreases in appetite, weight, and quality of life. Within the last year he was diagnosed with gastritis and inflammation of the colon, but at press time Zoo staff did not know the exact cause of his decline. A lightning strike he survived before his 2004 arrival at the Zoo may have contributed to his health issues. Although Ume will be missed, he leaves behind a great legacy—in 2005, he sired the second litter of cubs ever born at the Zoo, which were sent to other accredited zoos under the auspices of the Association of Zoos and Aquariums' Species Survival Plan for cheetahs.

In August, 12,000 new animals arrived at the Invertebrate Exhibit. They're all **elkhorn coral** (*Acropora palmate*), one of the world's most ecologically important reef-building coral. Like many coral worldwide, elkhorn are threatened by pollution and climate change, and in the Caribbean their populations have declined between 90 to 99 percent since the mid-1980s. A Zoo scientist and an Invertebrate Exhibit keeper traveled to Puerto Rico and captured the elkhorn as part of a collaborative project to protect the coral from extinction and to restore them in the wild. The coral raised at the Zoo may one day be returned to the ocean.

Work on Elephant Trails, the Zoo's innovative and stimulating new home for **Asian elephants** (*Elephas maximus*), has begun. But the Elephant House remains open and you can still see Kandula get his bath inside every day at 10:30 or watch him, Shanthi, and Ambika outdoors when weather permits.

Events

For more information, visit **www.fonz.org/events.htm**.

Mehgan Murphy/NZP

Celebrate Asian Elephants

November 17—10 a.m. to 3 p.m.

The Zoo and the Embassy of Sri Lanka are hosting this free event in appreciation of one of the world's most majestic species. Visit the Zoo's Asian elephants, including Shanthi, who was given to the Zoo in 1975 by the children of Sri Lanka. Outside the Elephant House, chat with Zoo scientists about their work to save this endangered species, enjoy Sri Lankan dancing, storytelling, and handicraft displays, and purchase Sri Lankan food. For more information, visit **www.fonz.org/elephants.htm**.

ZooLights

Wednesdays through Sundays from November 28 to December 30—6 to 8:30 p.m.

Winter nights sparkle at FONZ's first-ever lights event, powered by Pepco. Get cozy with a cup of hot cocoa as you walk through a wonderland of animal light sculptures, roast marshmallows, and enjoy live music and other activities at the Zoo. Tickets are $6 per night for FONZ members and $10 for nonmembers, and may be purchased beginning November 1 at **www.fonz.org/zoolights.htm**.

Mosca Design

On Our Website

Did you know you can find animal updates and get the inside scoop from animal keepers, curators, veterinarians, and scientists on our website? Visit **www.fonz.org/zoogoer.htm** to:

- Watch a video of giant anteater Aurora riding on her mother's back.
- Follow the Fujifilm Curatorial Resident as she goes behind the scenes with Asian small-clawed otters and African lions.
- Read about a day in the life of the Zoo's elephant manager.
- Hear what a Zoo biologist has to say about cheetahs in our "Cheetah Chat" podcast series.
- Find out how veterinarians treated an ailing cuttlefish from the Invertebrate Exhibit.

New Leadership

Mehgan Murphy/NZP

On September 10, FONZ welcomed Rita V. Burke as its new Deputy Executive Director. Burke joins FONZ after ten years serving in various managerial and advisory positions in the Fuels Marketing Division of ExxonMobil Corporation, most recently as a strategic adviser for global strategic planning. She earned a Bachelor of Science degree in biology from Occidental College in Los Angeles and a Master of Science degree in environmental engineering from the University of Houston. Since 2000, she has also served as a volunteer exhibit interpreter in the Zoo's giant panda and Asia Trail programs.

At FONZ, Burke manages a staff of more than 300 full-time and seasonal employees and oversees the organization's day-to-day operations, including visitor services, budget and finances, human resources, and organizational design and infrastructure. "I am thrilled and honored to join a staff so dedicated in its support of our nation's zoo and in its efforts to conserve biodiversity and inspire people to this important cause," she says.

Holiday Gift Ideas

Giving Tree

This holiday season, put your favorite Zoo animals on your gift list. Give them fun, exercise, and mental stimulation by donating enrichment items through FONZ's Giving Tree. Visit **www.fonz.org/givingtree.htm** to find out what the animals need and how you can help.

Shop National Zoo Stores

Need a special gift for the animal lover in your life? Look no further than the National Zoo. You'll receive a member discount at all stores in the Zoo and online at **http://store.fonz.org**.

Adopt a Species

Adopt a Species makes a great gift for a great cause. Adopt any of more than 30 species at **www.fonz.org/adopt.htm** for your loved ones and they'll receive a thank-you gift from FONZ and the satisfaction of knowing that your donation provides enrichment, habitat improvements, and medicine for Zoo animals.

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Jane Burton/naturepl.com

Is sleeping dangerous? Scientists debate whether animals like this young west European hedgehog (*Erinaceus europaeus*) are more vulnerable to predators when asleep than when awake.

To Sleep, PERCHANCE TO DREAM

by Jessica Marshall

"Oh sleep! it is a gentle thing, Beloved from pole to pole."
—Samuel Taylor Coleridge

Anyone who has ever stayed up too late and regretted it the next day knows just how much humans need sleep. Animals need it, too. Every animal studied so far—from whales to octopuses to fruit flies—sleeps, although animal sleep takes various forms, and even among mammals the human eight hours is not the norm. Horses, elephants, and giraffes, for instance, sleep only about two to four hours a day, while bats and opossums sleep up to 20.

It is obvious to us what it means to be asleep, but how do scientists know whether an animal that looks asleep is doing the same thing that we are? In some cases, they can record the animals' brain waves and compare them to those of sleeping humans. But in others, scientists have settled on a few observable criteria: Is the animal in a characteristic sleep posture? Is it unresponsive? Immobile? If it is deprived of sleep, will it then sleep longer to make up for lost zzz's?

Georgette Douwma/naturepl.com

Sleep research on invertebrates is not extensive. A recent study shows that snoozing pharaoh cuttlefish (*Sepia pharaonis*) periodically display a geometric pattern on the surface of their bodies, hinting that they may undergo two-phase sleep similar to that of mammals and birds.

Another behavioral criterion for sleep is that it is rapidly reversible, unlike hibernation, which takes a long time to enter and emerge from. Jerome Siegel, a neuroscientist at the University of California Los Angeles, says that hibernation is very much like sleep: Both help animals to conserve energy, but hibernation is more extreme. In hibernation, body temperature drops—sometimes to just a few degrees above freezing—and the brain truly shuts down, except for low-level brain activity needed to maintain functions such as breathing and circadian rhythms. Less drastic than hibernation is "shallow" torpor, in which an animal's body temperature drops, but not as low and for a shorter period of time. Some animals—like hummingbirds and hamsters—can enter and emerge from torpor daily.

"[Torpor] may be a compromise," says neuroethologist Niels Rattenborg of the Max Planck Institute for Ornithology in Starnberg, Germany. Animals in torpor save more energy than in sleep, but they are less responsive to potential threats. However, work by Craig Heller, a professor of biology at Stanford University, suggests that hibernation and torpor are not a substitute for sleep. He found that hibernating golden-mantled ground squirrels (*Spermophilus lateralis*) raise their body temperatures every five to seven days for about a day. During that time, they undergo slow-wave sleep—the deepest stage of sleep, characterized by slow brain waves—that is deeper than any other sleep they have when not in hibernation. Then they cool back down. So, even when animals have been inactive and resting during hibernation, they seem to need sleep.

"Current thinking is that brain structure is lost during a bout of deep hibernation, and it is growing back during these periods between bouts of hibernation," Heller says. "Until all of these neural connections are restored, the animals are less arousable and therefore sleep deeply." Animals emerging from shallow torpor also go straight into slow-wave sleep, which suggests a need for sleep on top of the time spent in torpor.

REM Sleep

One of the most inexplicable elements of sleep is REM, or rapid-eye movement, named for the fluttering motion of the eyes under the sleeper's eyelids. Unlike in deep sleep, which is characterized by slow brain waves, the brain during REM sleep is just as active as when it is awake. Dreaming happens during REM sleep in humans.

All land mammals and birds have REM sleep, but reptiles, amphibians, and fish appear not to. Rattenborg suggests that REM sleep may be involved in intelligence (as slow-wave sleep may be), because both birds and mammals have high cognitive abilities. "We have always joked and used the term 'birdbrain' to indicate that somebody's stupid," he says, "but birds are able to perform cognitive tasks that exceed some mammals."

If REM sleep is a hallmark of intelligence, then Stephen Duntley, director of the Sleep Medicine Center at Washington University in Saint Louis, wonders whether another notably smart class of animals—the cephalopods, including octopuses, squid, and cuttlefish—also experiences REM sleep. "They are incredibly intelligent," says Duntley, who has studied sleeping cuttlefish.

Like all cephalopods, cuttlefish have tiny organs called chromatophores in their skin that they use to change color in response to their environment. Duntley hypothesized that if cuttlefish "dream," they would continue to flash colors with their chromatophores, because they sleep in a protected environment where their color changes would not make them visible to predators. He found that pharaoh cuttlefish (*Sepia pharaonis*), which sleep under the sand, begin sleep with a light, monochromatic appearance, but every ten or 15 minutes they flash a geometric pattern of darker color unlike anything they display while awake. This suggests that cuttlefish also have alternating two-phase sleep, like the slow-wave and REM sleep of birds and mammals. It is still only a hint, though. Duntley has yet to monitor cuttlefish's brains during these flashing periods to determine whether this is truly similar to REM sleep.

A handful of mammals throw a wrench in the theory that brainy animals need REM sleep. Dolphins and other marine mammals, for instance, are some of the most intelligent animals known, yet "there have been no published reports documenting REM sleep in cetaceans, making them the only studied mammals in which this state has not been observed," writes Siegel in a 2005 paper in *Nature*. Further, most other newborn mammals get more REM sleep and spend more time sleeping than adults of their species, which suggests that sleep is important for brain development, but Siegel has found that dolphin neonates do not have any extended periods of sleep.

Another anomaly in REM sleep is the platypus (*Ornithorhynchus anatinus*), one of the most primitive mammals. The platypus does not tip any scales for cognition but has more REM sleep than any other mammal. Platypus REM sleep is "spectacular," Siegel says, with dramatic twitching of the bill and legs. Siegel's work with the platypus and one of the few other egg-laying mammals, the short-beaked echidna (*Tachyglossus aculeatus*), adds to the conundrum: His measurements of these animals show that they have REM sleep in the brain stem—a primitive part of the brain—and not the neofrontal cortex, which is more developed in higher mammals. "REM sleep is quite a mystery," he concludes.

To Each Its Own Sleep

Sleep might be universal, but animals have evolved different sleep patterns that suit their lifestyles. As omnivores who cannot seek food in the dark (24-hour diners notwithstanding), humans typically get their roughly eight hours of sleep in blocks, mostly during the night. But rats sleep in spurts that can happen any time of day, and they sleep ten to 12 hours a day.

Birds have varying sleep habits, too. As you might guess from the rooster's famous crowing at dawn, many birds sleep in one stretch, usually at night. But shorebirds sleep during the day or night, because they rely on low tides for finding food, which can happen at any time of the day. These birds have sensors in their beaks that allow them to find food even in the dark. Rattenborg and his colleagues studied white-crowned sparrows (*Zonotrichia leucophrys gambelii*) in the lab and found that they reduced their time spent sleeping by two-thirds during their migratory season, even though they stayed in their cages, hopping around and flapping their wings. Despite this lack of sleep, the birds showed no sign of sleep deprivation: Their performance on cognitive tasks was unchanged, and they did not sleep any extra to catch up after the migratory season ended. Now Rattenborg plans to track the birds while they are flying, because "It is possible that when they are up in the night sky with nothing to run into, they might nap," he says. The common swift (*Apus apus*), for example, spends almost its entire life in flight and may sleep on the wing. To test this, Rattenborg is using a wind tunnel specifically built for birds that has very smooth air flow. He is also using a mobile device to track the brain-wave patterns of birds in flight.

Sleep might be universal, but animals have evolved different sleep patterns that suit their lifestyles.

Jeff Rotman/naturepl.com

Unlike many infant mammals, young bottlenose dolphins (*Tursiops truncatus*) do not sleep longer or have more REM sleep than adults of their species.

In general, herbivores sleep less than omnivores, which sleep less than carnivores, perhaps because herbivores need to spend more of their waking hours

Philippe Clement/naturepl.com

Roosting sanderlings (*Calidris alba*) remain vigilant.

eating to meet their food needs. Small herbivores tend to sleep longer than large ones, perhaps because they need to conserve more energy to maintain their body temperature.

Herbivores may also spend less time snoozing because they can't sleep as safely as large predators. This may be true for certain animals that can sleep only in exposed environments, Siegel says, but he is not convinced that sleep poses a predation risk in most cases. "People might think, in theory, that animals are more vulnerable during sleep," Siegel says. "I think that is a fallacy." Most animals have evolved ways of sleeping that involve decreased risk, such as sleeping in burrows where they are relatively safe, he says. If sleep were more dangerous than being awake, animals might have evolved ways to rest parts of their brain at a time, rather than conking out all at once. But Rattenborg and ecologist Steven Lima of Indiana State University in Terre Haute propose that in most cases, for animals with complex, highly networked brains such as birds and mammals, unresponsive, "blackout" sleep may be safer than if these animals turned off pieces of their brain and wandered around without their full wits about them.

Yet some birds and mammals do forgo blackout sleep; instead, they keep one eye open and half their brain awake. For example, when mallard ducks (*Anas platyrhynchos*) sleep in groups, those on the outside edge sleep with their outside eye open and the opposite side of the brain (which controls the outside eye) awake.

T.J. Rich/naturepl.com

Cape fur seals (*Arctocephalus pusillus pusillus*) sleep differently on land than they do in water.

Presumably, the birds on the edge have to keep an eye out for predators while the birds in the middle can go fully to sleep. This behavior clearly suggests that birds are vulnerable during sleep, Rattenborg says.

Bottlenose dolphins (*Tursiops truncatus*) also sleep by closing one eye and shutting down the opposite half of their brain. While in this state, they may remain still or they may swim, avoid obstacles, and move both sides of their body, violating the "immobility" criterion for sleep. This suggests to Siegel that under such conditions the "sleeping" half of a dolphin's brain is not actually asleep, or is at least not experiencing blackout sleep.

But southern fur seals (*Arctocephalus* spp.) in the water truly sleep with half their brain, Siegel says. When one half of their brain goes to sleep, their opposing fins and whiskers become paralyzed. "When they are in water, which is where they live for six months of the year, they have very little REM sleep," he says. But when seals come on land, they sleep like dogs: Their whole brain goes to sleep and the brain-wave patterns match typical land-mammal patterns. They don't seem to need to catch up on the missed REM sleep.

Reptiles, amphibians, and fish all show sleep behavior. Although few studies have characterized their sleep, animals in these groups do not appear to have either slow-wave or REM sleep. Reptiles show some patterns that are "slow-wave like," Rattenborg says, but this is in strong contrast to the slow-wave patterns of birds and mammals, which are very easy to detect. Because reptile studies are not consistent, Rattenborg says scientists really don't know whether reptiles undergo slow-wave or REM sleep.

Work with insects and cephalopods has shown that invertebrates sleep, too. Paul Shaw of Washington University in Saint Louis reported in 2000 in *Science* that fruit flies (*Drosophila melanogaster*) sleep, based on behavioral measures: They don't respond if researchers tap lightly on their containers or pass a shadow over them. If the scientists keep the flies awake, the flies stay immobile for longer periods afterward, apparently to catch up on missed sleep. When Shaw's team gave the flies caffeine, they slept less.

Even some jellyfish may sleep. Jamie Seymour, director of the Tropical Australian Stinger Research Unit at James Cook University in Cairns, Australia, began tracking individuals from one species of box jellyfish (*Chironex fleckeri*) by gluing radio trackers

A red panda (*Ailurus fulgens*) sleeps on Asia Trail at the Smithsonian's National Zoo.

Mehgan Murphy/NZP

Jan Tyler/iStockphoto.com

It's unclear whether reptiles and amphibians have REM or slow-wave sleep like birds and mammals.

Aflo/naturepl.com

Like all land mammals, this Japanese macaque (*Macaca fuscata*) displays REM sleep, which may correlate with cognitive abilities.

to them. At first, Seymour and his colleagues thought the tracking devices were falling off, because the signals were falling to the ocean bottom. "It wasn't until we got in the water that we found the jellyfish were actually there, they just were not moving," he says. "Around about three or four o'clock in the afternoon, they would drop out of the water column and sit on the sea floor until the sun came up the next morning. The animals stopped pulsing. The tentacles were completely relaxed." Among jellyfish, *C. fleckeri* are unusual: They are active predators that can propel themselves through the water, and can grow two to three millimeters a day throughout most of their life span of a few months. They even show daily growth rings that suggest a 24-hour cycle marked by fast and slow growth. Seymour concluded that the jellyfish use their time on the bottom to redirect energy from moving to growing. "Whether it's sleep or not, I don't know," he says.

What Is the Purpose of Sleep?

Even though sleep may be universal, scientists are divided on why animals need it. Rats and flies deprived of sleep die faster than if they are deprived of food. This suggests that at least for some animals, sleep is essential.

Evidence is growing that animal brains need sleep for learning and consolidating memory. "The data are getting stronger each year," Rattenborg says. Studies of rats have shown that they experience more REM sleep after periods of learning, and that if deprived of REM sleep, they perform worse in mazes. Humans perform newly learned tasks faster after sleeping, but show no improvement after the same amount of time if they haven't slept. Shaw showed recently that the same phenomenon happens in fruit flies. Female fruit flies that have already mated reject males, but unmated females readily accept male advances. Shaw "taught" males that females would not accept their advances by introducing them exclusively to mated females. After this training, some males were sleep deprived for four hours while others were allowed to sleep as they desired. The males allowed to sleep slept extra long—more than if they had been kept awake all night. Three days later, Shaw exposed both sets of males to unmated females. Those that had slept did not court the females, indicating they had learned that females were unreceptive. Sleep-deprived males, however, showed no such restraint in courting the willing females.

Additional evidence from studies by neuroscientist Matthew Wilson at the Massachusetts Institute of Technology in Cambridge suggests that the brain replays events from the previous day during sleep, supporting the idea that the brain consolidates memories or learns during sleep. Wilson monitored the brains of rats as they ran a maze, measuring which neurons were active. During sleep that followed, he detected the same patterns of activity in the same sets of neurons that were activated when the rats were running the maze.

But Siegel finds much of this evidence unconvincing. He thinks the answer to why animals sleep is much more fundamental—they have evolved to sleep when there is no point in staying awake, when they are better off staying out of harm's way and saving their energy. For example, most cats sleep 12 to 15 hours a day. For a lion that has just killed an antelope, it makes sense to rest and digest for the next several days rather than using up energy or risking being injured when it does not need food, Siegel says.

Two species of bat (the big brown bat and little brown myotis, *Eptesicus fuscus* and *Myotis lucifugus*) sleep most of the time, because their food is available only for a few hours at night when their particular diet of insects emerges. They are better off sleeping the rest of the time, he suggests. In humans, the brain uses 25 percent of our energy at rest, so shutting it down could save significant energy, he says, and even small energy savings are significant in evolutionary terms.

Siegel acknowledges that for some animals sleep serves other functions, but he believes that these functions moved into sleep under evolutionary pressures that arose after the primary function of energy conservation. In humans, for instance, a growth hormone is released only at night in very deep sleep, and children deprived of such sleep by stress show stunted growth. But in dogs, a similar growth hormone is released during the day. "There must be a reason for this in humans," Siegel says. "There may be a whole lot of things like that that have migrated into sleep in different species that aren't universal."

Mehgan Murphy/NZP

An American flamingo (*Phoenicopterus ruber*) sleeps outside the Bird House at the National Zoo. Birds exhibit fascinating sleep behaviors; for example, birds of some species drastically reduce their amount of sleep during migration yet show no signs of sleep deprivation.

Animal Dreams

If Siegel is right, certainly one such phenomenon is dreaming. Dreams are a fascinating aspect of human sleep, but how widespread is dreaming in other animals? You have probably seen a dog twitching in its sleep; most people would assume it is dreaming. "From an evolutionary perspective, I think it's very unlikely that dreaming emerged for the first time in humans," Rattenborg says. Cats whose brains have been damaged in the part that normally keeps them paralyzed during sleep stand up and seem to attack imaginary things in their sleep: It appears they are acting out their dreams. The fact that all land mammals have REM sleep, which is associated with dreaming in humans, suggests that dreams are widespread. However, dream reports are uncommon or very simple in children between three and five years old, and people with certain types of brain damage have normal-looking REM sleep but never report dreams. So animals may not dream at all the way that we do, and because we cannot ask animals about their dreams, we will probably never know.

The fact that all land mammals have REM sleep, which is associated with dreaming in humans, suggests that dreams are widespread.

Nonetheless, researchers believe we have much to learn by studying animal sleep. Shaw's work with fruit flies has recently uncovered a molecule—the enzyme amylase—in their saliva that accumulates when they are sleepy. His team then found the same molecule in the saliva of sleep-deprived humans. This finding could eventually lead to a measure analogous to blood alcohol content to determine if bus drivers or shift workers are dangerously low on sleep. Manipulating the genes and monitoring various areas of the brain involved in sleep—experiments that can easily be done on fruit flies and mice—are also providing insights into what drives sleep at the molecular level. With many species' sleep never tested, the evolutionary patterns of sleep behaviors remain unclear. So sleep researchers can rest easy. There will be plenty of questions to keep them awake at night for years to come. Z

—Jessica Marshall is a science writer living and sleeping in St. Paul, Minnesota.

Peter Oxford/naturepl.com

All xenarthrans are likely descended from a Gondwanan ancestor that lived 100 million years ago. The group includes this silky anteater (*Cyclopes didactylus*) and the Smithsonian National Zoo's giant anteaters (*Myrmecophaga tridactyla*), as well as tamanduas, armadillos, and sloths.

Strange Joints

anteaters, armadillos, and sloths

by Susan Lumpkin

Sometime about 100 million years ago, when dinosaurs still dominated the Earth, a small animal, one of the first placental mammals, drifted away from its African relatives and founded a dynasty in South America. Freshly severed from Africa in the breakup of the Gondwana supercontinent, South America rested in "splendid isolation," as pioneering paleontologist George Gaylord Simpson put it in his fascinating 1980 book of the same name.

That primitive creature diversified into the hundreds of strange and wonderful mammal species—anteaters, armadillos, sloths, and more—known collectively as the Xenarthra. When, just three million years ago, a link was forged between North and South America at the Isthmus of Panama, some of these wonders crossed that bridge to found northern xenarthran dynasties of their own.

Wardene Weisser/Bruce Coleman Inc.

This model depicts a female giant ground sloth (*Eremotherium* sp.) foraging with her baby holding onto her fur. Ground sloths lived in the Americas more than 10,000 years ago, and some weighed more than 10,000 pounds.

Among the xenarthrans on both continents were many species of glyptodonts and pampatheres, some the size of rhinos. The beasts resembled armadillos but with better armor as protection from sabertooth predators. Some glyptodonts were truly huge—more than 16 feet long and five feet tall—and their heads, backs, and tails were covered with bony plates. The plates on their backs actually formed a rigid shell like a turtle's, but were ten feet long! One species wielded an armor-tipped tail like a mace to lash out at predators.

Ground sloths evolved in South America, too, and spread north, with one species reaching as far as Alaska. Based on fossils, scientists have identified four families of ground sloths (the classification level comparable to dogs versus cats) and nearly 90 genera. Some were small, and there were once even aquatic or semi-aquatic sloths, but many giant ground sloths lumbered across the land. The largest known of these plant-eating behemoths, *Eremotherium eomigrans*, was described in 2000 from fossils in Florida and likely weighed more than 10,000 pounds and reached 17 feet. This and similar giant sloths probably toppled trees for easier dining, much like elephants do. A member of a different family, Jefferson's ground sloth (*Megalonyx jeffersonii*)—the species that reached Alaska—was smaller, between eight and ten feet long, but still formidable.

Glyptodonts and ground sloths survived until as recently as about 10,000 years ago at the end of the Pleistocene epoch, when so many other of America's large mammals, from sabertooth cats to mammoths and giant short-faced bears, went extinct due to over-hunting by the first Americans, climate change, disease, or some combination of all three. But a few ground sloths hung on another 5,000 years on islands in the West Indies—until about the time the first people arrived on these islands.

Today, however, Xenarthra's surviving heirs are few. There are 21 species of armadillos, six species of sloths, and four of anteaters. And only one xenarthran, the nine-banded armadillo (*Dasypus novemcinctus*), lives in North America north of Mexico.

These small numbers, however, belie the remarkable diversity still remaining in the group. In the current classification scheme of mammals, which reflects what scientists know about how closely species and groups of species are related, the armadillos form their own order called the Cingulata—the same taxonomic level as, for example, Primates and Carnivora. The 21 species in nine genera come in a wide range of sizes. The largest, the giant armadillo (*Priodontes maximus*), weighs up to about 70 pounds, and the smallest, the pink fairy armadillo (*Chlamyphorus truncatus*), weighs a mere three ounces.

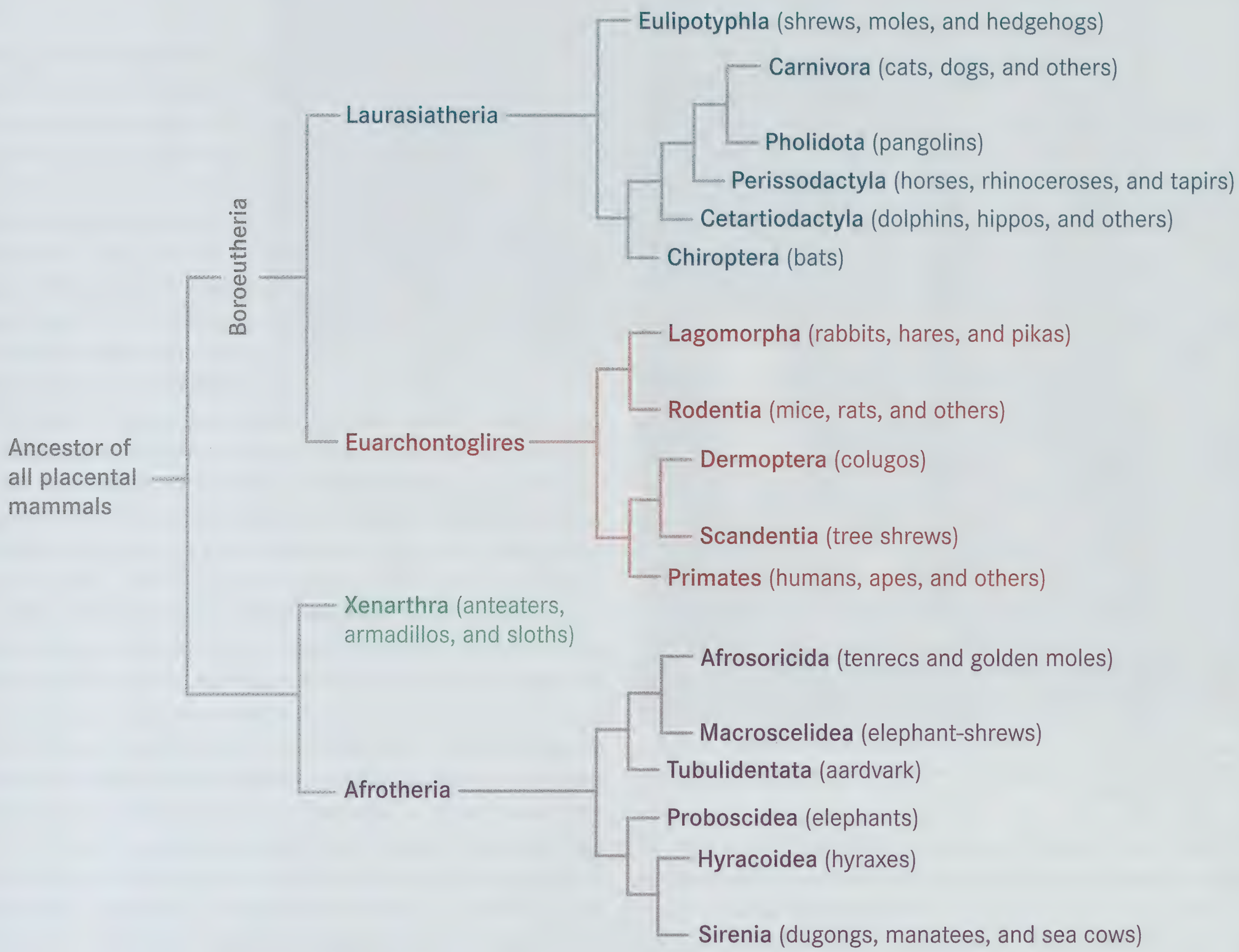
The living sloths—all arboreal leaf-eaters—and the anteaters, both arboreal and terrestrial, together form the order Pilosa. But the six sloths are divided into two families commonly called the two-toed sloths and the three-toed sloths. The 12 genera of the now-extinct ground sloths that survived past the end of the Pleistocene were all two-toed sloths.

The four anteaters, all toothless, are also divided into two families. The diminutive silky anteater (*Cyclopes didactylus*), about the size of a rat, forms its own family, while the giant anteater (*Myrmecophaga tridactyla*), which reaches 85 pounds, and the smaller, closely related northern and southern tamanduas (*Tamandua mexicana* and *T. tetradactyla*) form the other. Anteaters occupy both grasslands

A southern tamandua.

Anup Shah/naturepl.com

Placental Mammals



and forests from southern Mexico and Central America to South America as far as northern Argentina and Paraguay. Along with the xenarthran groups, they never extended into cooler northern climes, where ants are less abundant and only seasonally available.

These xenarthran oddballs, some of which lack teeth and all of which possess serious claws and have a tough time maintaining their body temperatures, hold what's left of the genetic heritage in one of the four major early dynasties of placental mammals. All four were founded and poised to diversify into many thousands of species when they inherited the world that dinosaurs abandoned 65 million years ago.

Strange Joints

Scientists have long recognized the Xenarthra as a group unto themselves and one of, if not the first, branch of placental mammals. The word xenarthra means "strange joints," a reference to the way their spinal vertebrae are linked, which is unique among mammals. At a higher level, the Xenarthra were once linked to other toothless oddities (some with teeth, but unusual ones) such as the ant-eating aardvark (*Orycteropus afer*) of Africa and scale-covered ant-eating pangolins (*Manis* spp.) of Africa and Asia. But in the past ten years or so, studies of molecular genetics have revealed that this seemingly sensible notion, based on physical similarities, is way, way off the mark. It turns out that the mammalian family tree is full of strange branches.

Take the group that vies with the Xenarthra for the title of first branch in the tree: another bunch of strange bedfellows called the Afrotheria (*theria* means mammal). Just as that South American drifter spawned creatures as diverse as armadillos, anteaters, and now-extinct giant ground sloths weighing 8,000 pounds, its African sister's living legacy includes elephants and elephant-shrews along with manatees and a few others, including aardvarks, which are thus more closely related to elephants than they are to anteaters. Like the Xenarthra, the Afrotheria once boasted a much larger number of species than today's approximately 50 surviving species in seven different orders.

Mehgan Murphy/NZP

This giant anteater is one of three of its species on exhibit at the National Zoo. Its curved claws fold up behind its knuckles and wrists when it walks.

Whether it is entirely accurate to call the first xenarthrans and afrotherians "sisters" is the subject of much genetics research. Geneticists use various techniques, data sets, and analyses to create their trees, with sometimes conflicting results. Some trees do show the Xenarthra and the Afrotheria as sisters, meaning they share a common ancestor, and stepping back in time, that common ancestor is sister to the common ancestor of all other placental mammals. Other trees suggest that one or the other was first, meaning that the Afrotheria shared a single common ancestor with all of the other mammals, including the Xenarthra, which split off soon after, or vice versa.

There is scientific consensus, however, about the next groupings, or as scientists call them, clades. Whatever was its sister clade, the Boreoeutheria (for "northern true mammals") split next, soon followed by a division into the Laurasiatheria (Laurasia is the name of the northern hemisphere supercontinent formed of North America, Europe, and Asia) and the Euarchontoglires (a tongue-twister with a convoluted meaning), the last two of the major placental mammal lineages. These clades contain some surprises too. Humans and other primates, as well as rodents, rabbits, tree shrews, and flying lemurs, or colugos, belong to the Euarchontoglires. All the rest of the mammals, from bats to cats and horses to hedgehogs, are members of the Laurasiatheria. And ant-eating scaly pangolins, once thought to be akin to xenarthrans, instead share a common ancestor with Carnivora such as cats and dogs.

Worm Tongues

The family name of anteaters is Myrmecophagidae, which means, not surprisingly, "ant eater," although their diets may include termites as well. Another name proposed for these animals is vermilinguas, meaning "worm-tongued." All of the anteaters (and the pangolins, by the way) have extraordinarily long tongues, with very long faces, most extremely so in giant anteaters, to accommodate them. The giant anteater can extend its tongue two feet beyond the end of its snout and retract it again as often as 160 times a minute, covered in ants or sometimes termites that adhere to its sticky saliva. Such speed is crucial to these animals getting enough to eat because soldier ants and termites don't take kindly to invasions of their mounds. Using the long sharp claws on their powerful forelimbs, anteaters break into ant and termite mounds and begin slurping up the insects that stream forward. But almost immediately, soldiers begin rushing into the breach and start biting the predator's nose. As the amassing army gets bigger, the anteater extends its tongue farther and farther out of its mouth and away from the mound and its biting defenders. In less than a minute or so, however, the anteater surrenders, and moves on to sup briefly in another mound in its home range. Fortunately, ants and termites are abundant in the tropical forests and grasslands in which the giant anteater lives, and it visits many nests to get its fill of thousands—perhaps as many as 30,000—of ants per day.

However many an anteater eats in a day, ants and termites are not very nutritious food. As a result, anteaters are adapted to conserve energy. Giant anteaters tend to move slowly from meal to meal, and have a curious shuffle thanks to the fact that they walk on the knuckles of their front feet, much like gorillas and chimpanzees do. This protects their claws, which fold up behind the knuckles and wrist. Anteaters use their claws not only to break into mounds but to dig, to fight with other anteaters, and to defend against jaguars and pumas, their only predators, besides humans.

Anteaters also conserve energy by not using as much as other mammals do to maintain a high body temperature. Most mammals maintain body temperatures between 95 and 100°F; anteaters' body temperatures, in contrast, range between 90 and 95°F. Their basal metabolic rate—the amount of energy a resting, warm animal uses to maintain its vital organs—is 29 to 33 percent that of similar-size mammals. Their thick, long fur keeps them from losing as much heat as other mammals, too. And to sleep—up to 14 hours a day—they use their claws to dig a shallow depression, lie down in it, and cover themselves with the long furry tail that makes up about half of their six-foot length.

Anteaters not only move slowly, they live slowly. Born after a relatively long gestation of up to 190 days, a newborn giant anteater—

Jessie Cohen/NZP

A southern three-banded armadillo at the Zoo's Small Mammal House.

litter size is one in all anteaters—weighs about three pounds and is fully furred, with adult markings. Immediately, the baby has the motor skills to climb onto and cling to its mother's back. Mother and baby are virtually inseparable for months. A baby nurses for about six months, but may ride around on its mother for nine months or a year, and doesn't leave its mother for a solitary life until it's about two. If it escapes predators, fires, and other threats, it may live a long time. Although life spans in the wild are not known, the record longevity of giant anteaters in zoos is about 30 years.

Pete Oxford/naturepl.com

Pangolins are not closely related to xenarthrans.

A Not-so-Giant Future?

Giant anteaters are found over a large geographic area, from parts of Central America through South America east of the Andes as far south as northern Argentina and Uruguay. Always uncommon, they appear to be declining and may be extinct in some places, including much of Central America and Uruguay. In Brazil, they are confined to national parks and reserves; anteaters studied in one park, which boasts one of the largest populations, are highly inbred. Because so little is known about these animals, however, the World Conservation Union (IUCN) lists them as "near threatened" on the Red List of Threatened Species, which means that the species is close to becoming or likely to be labeled as vulnerable or endangered in the near future. The litany of threats to giant anteaters is familiar: Ongoing loss of habitat to crop and pasture land, human settlements, and uncontrolled grassland fires set to clear land for agriculture. Believing them to be dangerous, farmers kill them as pests, and the slow-moving animals are hit by vehicles on roads and attacked by domestic dogs. Some indigenous groups in Brazil and elsewhere hunt giant anteaters for meat, preferring their taste to that of other wild species—in some areas, unsustainable hunting is a more serious threat than habitat loss.

The Smithsonian's National Zoo and several other North American zoo members of the Association of Zoos and Aquariums are breeding giant anteaters, hoping to build a healthy zoo population in case the species slips into further trouble in the wild. The first birth of a giant anteater at the Zoo, a female named Aurora, represents an important step toward achieving that goal. (See Notes & News on page 6).

The outlook for the rest of the xenarthrans is mixed. A few are doing fine and a few more are known to be in serious trouble; most, however, are so little studied that their status is determined by educated guesses, not rigorous research.

Tamanduas and the silky anteater are considered of "least concern" by the IUCN, although there are ominous questions about trends in their numbers. Similarly, all but two of the sloth species are of least concern, including the Linnaeus' two-toed sloth (*Choloepus didactylus*) in the Amazonia exhibit at the Zoo. But again, population trends are unknown. One, the maned sloth (*Bradypus torquatus*) is found only in the disappearing coastal forest of Brazil and is endangered. Another, the pygmy three-toed sloth (*B. pygmaeus*), is critically endangered; this species lives only in mangrove forests on a single island off the coast of Panama, and these forests cover only about half a square mile of the island.

Nearly half of the 21 armadillo species are of least concern, with trends in their numbers mostly unknown. So little is known about two of the species that no judgment about their status is possible. Ten species are near threatened or vulnerable. Habitat loss threatens most of the armadillos, but subsistence hunting for food is also a significant threat to most. Many people find armadillos very good eating. If that seems strange, consider that the white meat of nine-banded armadillos, which weigh from about seven to 14 pounds, tided Texans over during the Depression, and you can still find recipes for armadillo online.

Hunting hasn't had a big impact on the versatile nine-banded armadillo, which has the widest range of all the xenarthrans and, for a member of this group, a large litter size of four. In fact, this species has been steadily expanding its range and growing in numbers in the United States since it first crossed the Rio Grande about 150 years ago, probably assisted by people looking for meals as the wide river itself represented a significant barrier. People also helped nine-banded armadillos cross the Mississippi, taking them to Florida in the early part of the last century. From these two fronts, they've naturally colonized Louisiana, Arkansas, Oklahoma, Alabama, Mississippi, and Georgia, and scientists predict they will continue to march northward, limited only by extreme winter temperatures and the need for water. They would do fine in Washington, D.C., and New York City, for instance. One armadillo species already makes its home in Washington: five southern three-banded armadillos (*Tolypeutes matacus*) live in the Small Mammal House at the Zoo.

The remaining xenarthrans hold a significant portion of the genetic diversity of the mammals. It would be a shame to lose any more species of a group with such a long history, whose very strangeness makes learning more about its members all the more important to our understanding of mammalian evolution. Z

Gila monsters have a longstanding reputation in the U.S. Southwest as man killers—their very name suggests they are a menace. Yet there have not been any recorded human fatalities from Gila monster bites in the last 50 years.

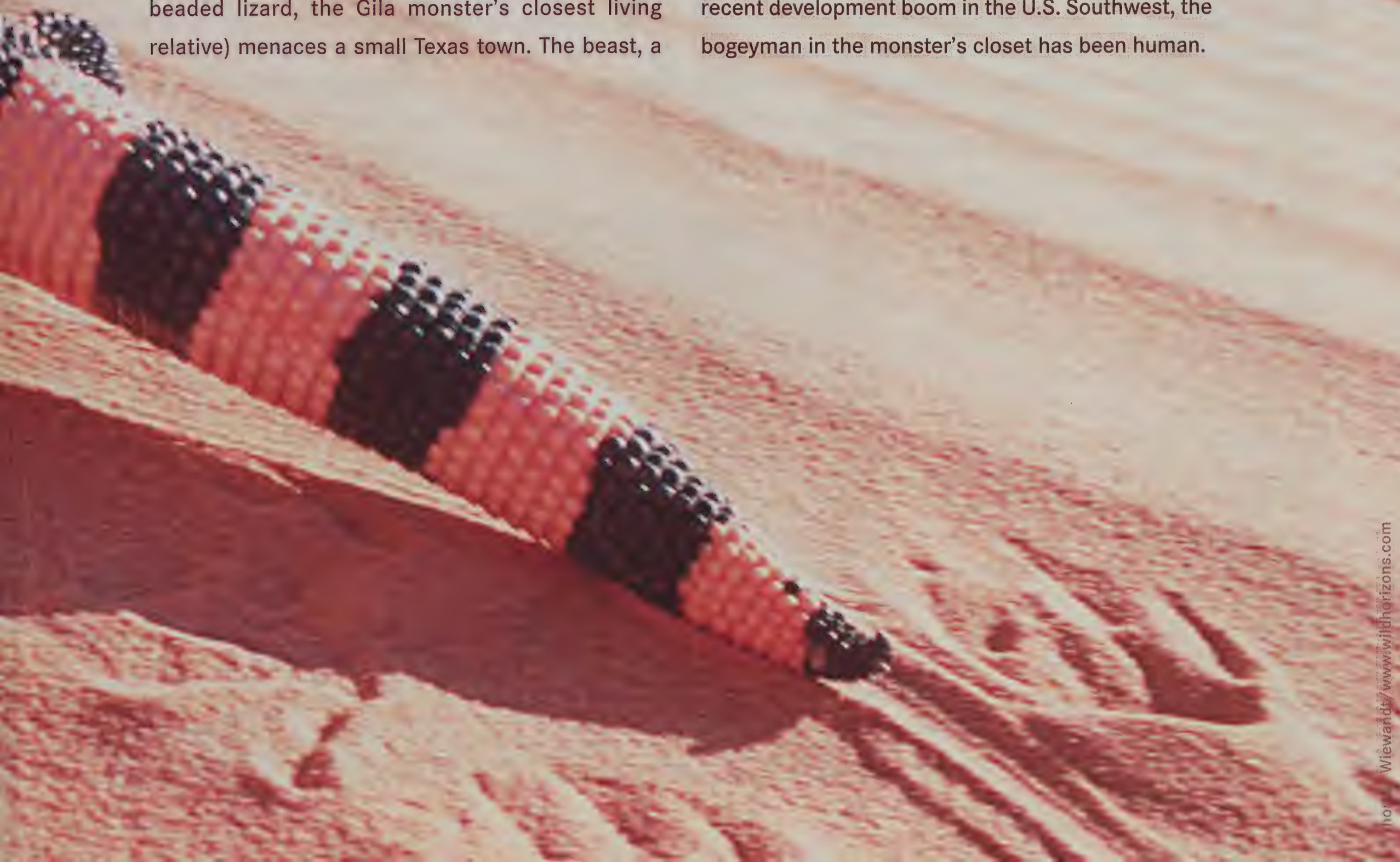
myths & MONSTERS

by Alex Hawes

"What is this black menace that kills everything it sees and hears?" implores the solemn narrator in the trailer to the 1959 film, *The Giant Gila Monster*. "No human mind could imagine the enormous destructive power of this maddened, killing thing. If you're young people in love, look out! If you're driving down a lonely road, you're as good as dead."

In this splendidly cheesy B-movie, a rampaging, train-engine-size Gila monster (played by a Mexican beaded lizard, the Gila monster's closest living relative) menaces a small Texas town. The beast, a freak result of an overzealous pituitary gland, swallows a hitchhiker, overturns a fuel truck, and, most disturbingly, interrupts a local sock hop. In the end, the film's hero blows up the beast using a hot rod packed with nitroglycerin.

Gila monsters (*Heloderma suspectum*) haven't fared much better in real-life confrontations with people. From Western scientists' first written description of Gila monsters in the mid-19th century to the recent development boom in the U.S. Southwest, the bogeyman in the monster's closet has been human.



Wiewandt / www.wildhorizons.com

Thomas Wiewandt/www.wildhorizons.com

Gila monsters have evolved to survive in the arid, subtropical Sonoran Desert. Unlike most lizards, they use their urinary bladders to store water and stave off dehydration, and water evaporates from their skin and cools them down.

No record exists of a real Gila monster killing a person in more than 50 years, yet fear of this animal's lethal bite undoubtedly fuels the historic hysteria surrounding it. Gila monsters and Mexican beaded lizards (*H. horridum*) are the only known venomous lizards in the world, and over the years they have been falsely credited with the ability to spit or belch toxic potions, withstand the crush of 50-pound boulders, and wither surrounding vegetation with a single drop of their deadly saliva.

Ignorance about these reclusive creatures is not confined to popular culture. "There is more nonsense in the scientific and medical literature on the Gila monster than on all the other venomous reptiles in Arizona combined," write Charles Lowe, Cecil Schwalbe, and Terry Johnson in the 1986 book *The Venomous Reptiles of Arizona*. The biggest scientific myth may be that Gila monsters—which are descended from tropical ancestors—are maladapted to the arid, subtropical Sonoran Desert of Arizona and northern Mexico. Their adaptations for energy conservation and thermoregulation suggest otherwise.

"They've been here as long as the Sonoran Desert's been here," says Dale DeNardo, an environmental physiologist and attending veterinarian at Arizona State University in Tempe. "They *must* be adapted well."

According to the fossil record, modern Gila monsters have changed little during their 20,000-plus years as a species.

Life in the Slow Lane

Gila monsters and beaded lizards are descended from an ancient reptile clan, the Monstersauria, once found across North America, Europe, and Asia, beginning about 100 million years ago. Today, they constitute the entire Helodermatidae family, which takes its name from the Greek words *helos*, meaning "nail stud," and *derma*, meaning "skin." According to the fossil record, modern Gila monsters have changed little during their 20,000-plus years as a species. Adults typically reach lengths of 16 to 24 inches, from snout to tail tip. In the wild, the average weight for an adult Gila monster is just over a pound, and on rare occasions an adult may weigh two pounds.

Biologists traditionally split Gila monsters into two subspecies, reticulate and banded, according to regional variation in skin pattern. They range from the southern reaches of the Mojave Desert in Utah, Nevada, and California, through their core habitat in the Sonoran Desert of Arizona and northern Mexico, to the extreme western edge of the Chihuahuan Desert in New Mexico—and from scrub plains near sea level to pine forests a mile high.

Gila monsters spend as much as 95 percent of the year holed up in rocky crevices, badger burrows, packrat middens, and other prefabricated dwellings, according to herpetologist Daniel Beck,

who wrote the definitive 2005 treatise, *Biology of Gila Monsters and Beaded Lizards*. In winter months, six or more Gila monsters may share a single shelter to seek protection from the elements or predators. They emerge from winter shelters between January and March to bask and sometimes hunt, but their activity peaks in April and May as they seek mates, food, and deeper, cooler shelters for the hotter months.

Jessie Cohen/NZP

The bumpy skin of one of the Smithsonian National Zoo's Gila monsters.

Field researchers find it difficult to tell male and female Gila monsters apart at first glance. However, males display higher stamina and slightly larger skulls, which are both possible adaptations for their dramatic breeding-season wrestling bouts. These duels may last as long as 12 hours, but the payoff is worth it: The victor gets access to females and their shelters. Mating typically takes place in spring within the privacy of underground retreats, and six to eight weeks after copulation, females lay clutches averaging a half-dozen eggs. After the breeding season, adult lizards return to an asocial lifestyle, confronting the difficulties of desert survival in solitude. There is no evidence that the female incubates the eggs or that either parent is involved in caring for the young after they hatch. The eggs remain underground through the winter and the young hatch the following spring.

Helodermatid lizards are the only nest-predator specialists in their desert habitat. A single meal, such as a half-dozen quail eggs, can satisfy a Gila monster's energy needs for up to four months. Typically, reptiles, amphibians, and other ectotherms burn 20 to 40 times less energy than comparably sized mammals, but the Gila monster is the Toyota Prius of the animal kingdom. With metabolic rates among the lowest of any lizard measured, relative to weight, Gila monsters can draw upon the fat of a feast slowly and go months between meals. By storing fat in their sausage-shaped tails and abdomens, Gila monsters can spend less than 100 hours a *year* active at the surface—a typical work week for a high-metabolism Wall Street broker. In contrast, humans and other endotherms—animals that control their internal body temperatures with metabolic energy—need to eat much more frequently. Even eating-contest champions, who can bolt nearly 20,000 calories worth of hot dogs in 12 minutes, are only swallowing enough to last an average man eight days.

One might be tempted to call Gila monsters sluggish, at least from a safe distance, yet they demonstrate surprising stamina. Beck has fitted helodermatid lizards with oxygen masks and run them on treadmills to measure their aerobic capacity. Although the lizards could only muster top sprint speeds of barely one mile per hour, each species was capable of ambling along at a steady half-mile-per-hour pace for great lengths of time. One beaded lizard, a true Energizer Bunny, continued for so long—nearly four hours—that the exasperated lab technician relented and unplugged the treadmill.

Regulating heat and hydration is a year-round concern for Gila monsters and all ectotherms. "Temperature kills much more quickly than starvation," says DeNardo. Gila monsters can become paralyzed or convulsive if stranded aboveground at temperatures exceeding 108°F—a mark frequently surpassed in the Sonoran in summer. Beck has never witnessed Gila monsters willingly active at triple-digit temperatures. Instead, they escape heat exhaustion and dehydration in cool burrows.

This low tolerance of high heat has led some to question Gila monsters' desert credentials. The Sonoran Desert is a mere eight million years old; helodermatids had evolved up until that point in tropical deciduous forests similar to those inhabited by modern Mexican beaded lizards. Perhaps Gila monsters are truly tropical at heart. However, keeping cool in the desert gives them one crucial benefit: Metabolic rates drop with body temperature. A decline from 80 to 60°F, according to Beck, cuts a lizard's metabolic rate in half. Like your laptop, a Gila monster in hibernate mode consumes practically no energy—and it needs little food.

Gila monster females lay their eggs underground in late spring or early summer, and the eggs hatch the following spring.

Thomas Wiewandt/www.wildhorizons.com

A Taste for Toxin

There may be a reason why so few nest predators exist in the desert: empty nest syndrome. During the spring or during the summer monsoon, Gila monsters diligently forage for the eggs of quail, doves, lizards, and tortoises, as well as for newborn nestling rabbits and rodents. The lizards must gorge themselves when possible, then rely on their slow-motion metabolism to pull them through the lean months. It is truly feast or famine.

Raiding nests is no picnic. Ground squirrels (*Spermophilus* spp.), desert tortoises (*Gopherus agassizii*), and other protective parents vigorously defend their young. First, though, Gila monsters must *find* the nests, which are often cleverly camouflaged. "In eight years [studying Gila monsters in the field], I've seen three bird nests and one cottontail [rabbit] nest," says DeNardo. "I wouldn't make a good Gila monster." With their acute sense of smell, Gila monsters may decipher chemical trails left by small animals that lead them to their prey.

Capturing defenseless nestlings and motionless eggs requires little agility—and no venom. Helodermatids bear potent toxins not for killing quarry, but to defend themselves against coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and other predators encountered during their long, slow treks for food or mates.

Gila monsters' skin pattern of mottled black splotches set against a field of coral pink, vermilion, or orange conceals them well amid the desert vegetation. But when a predator does discover a Gila monster, the lizard freezes, then slowly backs away while hissing and presenting its tail. ("It's better to have a third of a tail eaten than to lose your head," notes Jon Davis, a doctoral student in DeNardo's laboratory.) Meanwhile, it begins coating its teeth with toxic saliva.

Thomas Wiewandt/www.wildhorizons.com

Gila monsters may use their acute sense of smell to help them locate and raid bird nests for nutritious eggs.

If attacked, it retaliates with the tenacity—and bite—of a bulldog. One literally needs a crowbar to pry off a gnawing Gila monster. This biting strategy ensures the delivery of sufficient venom to stun or immobilize an assailant.

Venomous snakes like rattlers and cobras typically strike large-bodied prey before retreating out of harm's way to let the poison kick in. Lizards, however, lack this strike capacity—which, Beck writes, may explain why only two venomous lizards exist. Gila monsters must chomp down on an attacker, keeping it perilously close at hand, as tension in their jaw muscles delivers venom into the wound through their special grooved teeth.

Helodermatid poison appears most effective against endothermic animals. It can reduce blood flow and cause symptoms ranging from internal hemorrhaging to vomiting, respiratory failure, and cardiac arrest. These toxic chemicals may stimulate not just excruciating pain in a victim, but heightened memory of the biting episode—a powerful souvenir to prevent future encounters.

A Gila monster bite has never been known to kill a healthy person, given appropriate medical care. Toxicologist Findlay Russell of the University of Arizona in Tucson extrapolated from studies of mice dosed with Gila monster venom that it would require 32 to 70 milligrams of helodermatid toxin to kill a 150-pound man. Gila monsters, however, store no more than about 20 milligrams at a time—perhaps enough to kill an infant, according to toxicologists, although children are much less likely to be bitten by a Gila monster than by a rattlesnake. (For comparison, certain snakes may store up to 850 milligrams in their venom glands, although they typically deliver a small fraction of this with each bite.)

Nonetheless, stories abound of deadly encounters between man and monstersaur.

A Gila monster must clamp onto prey with its teeth to deliver its venom, which is not lethal to adult humans but can cause them excruciating pain.

Thomas Wiewandt/www.wildhorizons.com

In David Brown and Neil Carmony's entertaining 1999 book *Gila Monster: Facts and Folklore of America's Aztec Lizard*, the authors highlight a host of historic accounts, some stretching the limits of believability. In one of the last alleged fatalities (March 1953), a Nevada man, following two beers, five scotch-and-sodas, and six martinis, played "Russian roulette" by sticking his finger in and out of a Gila monster's mouth. (He lost.) Another anecdote involves a parachutist blown straight into a lizard's waiting jaws.

Being bitten by a Gila monster is apparently quite an accomplishment, requiring either excessive alcohol, terrible luck, great stupidity, or all three. The Samaritan Regional Poison Center in Phoenix, Arizona, treats about one bite case per year on average. The advice, if bitten, is simple: Remove reptile! Daniel Beck writes, helpfully: "A thin, flat lever inserted between the lower jaw and the flesh and turned 90 degrees may work to quickly release the jaws. ...I do not recommend trying to remove the lizard by applying a flame to its chin or by using dangerous solvents such as gasoline."

Yet the poison so feared by many desert dwellers is helping people far more than it is hurting. Gila monster venom contains a peptide called exendin-4 that resembles a hormone humans release during digestion. In Gila monsters, the concentration of exendin-4 in the bloodstream surges thirtyfold following a meal, perhaps to help them stomach large meals. This detail attracted the attention of John Eng, an endocrinologist at the Bronx Veterans Affairs Medical Center in New York. Partnering with Amylin Pharmaceuticals, Eng and his colleagues investigated and then patented exendin-4 as a treatment for type 2 diabetes.

The poison so feared by many desert dwellers is helping people far more than it is hurting.

Roughly 21 million Americans have type 2 diabetes, an adult illness associated with obesity that can cause blindness, kidney failure, and in rare cases, death. Diabetics can't effectively produce insulin; without it, dangerous levels of glucose build up in the body. In conjunction with other medications, exendin-4 stimulates the pancreas to produce sufficient amounts of insulin. It is also less likely than other diabetes treatments to create excessively low levels of glucose, which can lead to comas or even death.

In September 2002, Amylin Pharmaceuticals sold rights to a synthetic version of exendin-4 to Eli Lilly and Company for $325 million. The drug, marketed now under the trade name Byetta, received Food and Drug Administration approval in April 2005. In addition to regulating insulin production, Byetta has been found to suppress appetite, a significant benefit for sufferers of this weight-triggered ailment. In one trial, patients prescribed Byetta shed an average of five pounds over six months, while diabetics taking traditional insulin injections gained four pounds on average.

Another chemical in Gila monsters, a hormone called gilatide, may one day help people suffering from memory ailments like Alzheimer's and attention deficit disorder. Analysts predict that helodermatid-inspired drugs could soon generate pharmaceutical revenues in the billions.

The Witching Hour

Sadly, Gila monsters are more often bulldozed than thanked for their contributions to mankind's welfare. People and their cars, pets, and homes pose the greatest threat to Gila monster survival. The population DeNardo and Davis studies in rural Pinal County, Arizona, for example, is feeling the squeeze of sprawl from Phoenix to the north and Tucson to the south. "This area will probably be all houses in ten years," says Davis.

Davis and DeNardo won't publicly disclose the location of their study site in Pinal County, due to the threat of poaching. The impact of poachers on Gila monster populations remains unclear, but the lizards are popular in the exotic pet trade and can fetch up to $1,500 each on the black market, according to Davis. While not considered endangered, Gila monsters nonetheless receive full state protection across their range, shielding them from unlicensed collection, transportation, and killing. The Arizona Game and Fish Department estimates that up to 40 Gila monsters are poached every year in the Tucson region alone. The agency has begun

A scientist extracts venom from a Gila monster's mouth. A synthetic version of a peptide in the venom is used to treat patients with type 2 diabetes.

Thomas Wiewandt/www.wildhorizons.com

Thomas Wiewandt/www.wildhorizons.com

Suburban sprawl is transforming portions of the Gila monster's Sonoran Desert habitat into dangerous territory for the lizards. Backyard swimming pools appeal to the monsters, but once they drop in, they may drown if they can't find a way out.

implanting microchips to track live, decoy lizards.

Harm can come from good intentions, too. Every year, dozens of Gila monsters and hundreds of rattlesnakes are moved away from residences in Phoenix and Tucson to supposed safety. Brian Sullivan and his colleagues at Arizona State University followed 25 "nuisance" Gila monsters that had been relocated within the Phoenix region. They found that lizards brought to undisturbed desert habitat more than a kilometer [more than half a mile] from their point of capture subsequently traveled six times the usual distance per day, perhaps in a vain attempt to find their way home. All either went missing or died—victims, potentially, of starvation or increased exposure to predators.

Gila monsters seem to do best if simply left alone. "It feels good to take a Gila monster to the beautiful desert, release it, and go home smiling. But just because it feels good, doesn't mean it's right," says DeNardo.

One evening, I follow another Gila monster researcher, Patrick Emblidge, through rocky terrain just north of St. George, Utah. Emblidge—along with Beck, his advisor at Central Washington University in Ellensburg, Washington—is examining Gila monster habitat use in the desert surrounding St. George. It is a balmy, 97°F July night. We track one of his four radio-implanted individuals up a steep sandstone outcrop. The chirps emanating from his radio lead us to the softball-size entrance of a darkened burrow, where our Gila monster is sensibly holed up for the moment.

St. George's warm climate and proximity to Zion National Park, the Grand Canyon, and other national treasures have drawn snowbirds by the thousands. The city, in fact, grew faster than any other metropolitan area in the U.S. between 2000 and 2006, adding nearly a thousand new residents a month. "[Gila monsters] are getting crushed between development to the north and their elevational limits," says Emblidge. Ironically, the individual lizard whose saliva led to the discovery of exendin-4 likely came from St. George.

One further irony: The best hope for the Gila monster may be a species whose eggs it hunts, the desert tortoise. Extraordinary measures have been taken recently to protect portions of this threatened tortoise's habitat, including the creation in 1996 of the 62,000-acre Red Cliffs Desert Reserve outside St. George. The reserve may also be one of the last safe places left for Gila monsters in the Mojave. Desert tortoises, which gravitate toward creosote-dominated flatlands, don't perfectly overlap with Gila monsters in the Mojave. Emblidge hopes, however, that his project will help guide those protecting desert tortoises to select habitat that likewise benefits Gila monsters.

Emblidge's project includes another inspiring goal: to share his research with St. George's most impressionable minds. Emblidge and Beck have teamed up with local schools to teach first and fourth graders radiotelemetry skills, graphing techniques to plot shelter locations, and, above all, the beauty and value of these rare creatures.

"It's good to increase awareness where possible," says Emblidge. And not to believe everything you see at the movies. Z

—Alex Hawes is a teacher and nature writer in the Grand Canyon State, which is home to a dozen venomous reptile species.

Gila monsters can be seen at the Smithsonian National Zoo's Reptile Discovery Center.

Last Remains

The World Without Us
Alan Weisman. 2007. St. Martin's Press, New York. 324 pp., hardbound. $24.95.

A new map of the region surrounding the great Cambodian temple of Angkor Wat recently revealed that dense jungle hides traces of a human settlement that covered about 2,000 square kilometers (about 770 square miles). Between 400 and 1,200 years ago, this settlement, once full of temples, roads, canals, and rice fields, was the size of New York City and Los Angeles combined. Yet, in just a few hundred years, it and the culture that built it vanished from view, detectable today only by sophisticated analyses of radar data and aerial photography. Similarly, but on a smaller scale, the remains of the Mayan cities of the Yucatan disappeared for centuries until 20th-century archeologists hacked them out of the exuberant tropical vegetation jungle that smothered them.

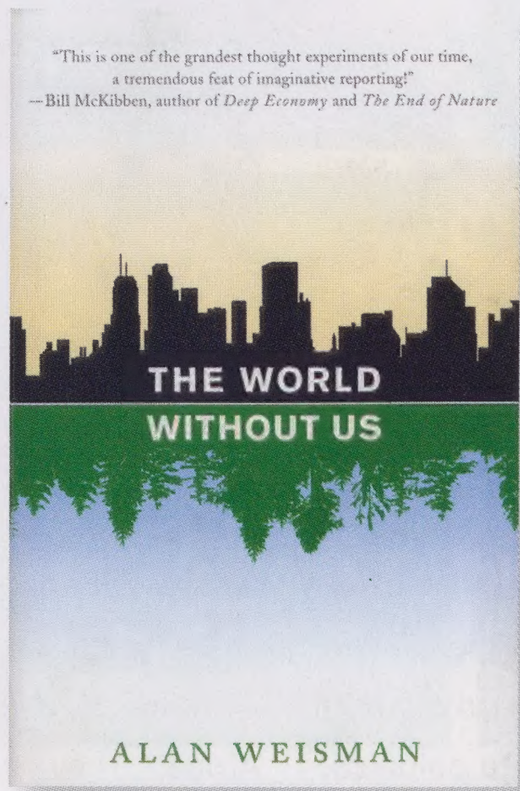
People often speak of our fragile planet but, left alone, it's anything but. Natural forces have a way of wreaking havoc on our built environments, eventually reducing to faint scars our impressions on the Earth. At least in most cases, and for most of human history. But today we do not live lightly on the land. Our artifacts, edifices, and detritus seem more permanent, our effects on wildlife and wild lands more enduring than at any time in the past. But are they?

This is the question Alan Weisman asks in *The World Without Us*. If people disappeared now, what traces would remain of our civilization in ten million years, or even in 100 years? And how would the natural world fare?

Start with Manhattan, whose "...sheer titanic presence...resists efforts to picture it wasting away." Yet it would, and rather quickly, once, just days after we left, the city's vast subway system would flood without crews to man the 753 pumps that keep the water at bay. It would be a few centuries or so before the city's bridges tumbled into the river and Manhattan was truly an island again.

Meanwhile, indigenous plants and animals would reclaim the land from most of the alien invaders that displaced them, with wolves, bears, moose, and beavers living in marshes and mature oak forest. Wildlife on more isolated islands would face dimmer futures. Unchecked by our control programs, mongooses, rats, and other predators introduced to Hawaii, for instance, would run amok and likely finish the job of driving native bird species into extinction. Similarly, kudzu could smother parts of the U.S. South.

The Statue of Liberty, made of nearly indestructible bronze, would last indefinitely, even after it fell into the sea. Aluminum objects would probably also last as close to forever as we can think about. Plastics may too—unless some species evolved to digest them, a not-too-farfetched notion given studies that suggest virtually all sea creatures ingest large amounts of the plastic we've dumped into the oceans. In fact, the reason that the billion tons of plastic produced in the last 50 years don't dominate landfills is that most of them end up in the ocean. In the North Pacific Subtropical Gyre, a patch of ocean between California and Hawaii whose vortex captures refuse, millions of tons of plastic swirl over an area almost the size of Africa. Weisman wonders whether geologists millions of years from now would discover Barbie doll parts in the seabed and piece them together like we do dinosaur fossils today.



Weisman's exploration of the future without us is wide-ranging. He traces the history of human impacts on Africa and predicts the continent will revert to the "purest primeval state on Earth." He describes how the Panama Canal works and how it would disappear in a few years; like the New York subway system, its maintenance requires constant human attention. On the other hand, the visage of Teddy Roosevelt, who directed the canal's construction, would remain visible on Mount Rushmore for tens of thousands of years.

Weisman delves into the problems of nuclear waste storage and burning petrochemical plants as well as the fates of farmlands and coral reefs. He explores an ancient underground city in Turkey, some 18 stories deep, whose rooms and roads will outlast all vestiges of modern megalopolises. He even discusses embalming and burial practices meant to preserve our bodies that cheat the soil of our fertilizing nutrients!

Will any creature miss us when we're gone? Unlikely, according to Weisman, except our pet dogs, perhaps—and the lice, mites, and bacteria that live only on the human species. He also notes it's unlikely that "zookeepers from outer space" will save us from whatever catastrophe, which some predict will be a new technology gone awry, threatens to wipe us off the face of the Earth.

Eventually, all traces of us would disappear, as "anything truly intractable would end up buried, to one day be metamorphosed or subsumed into the planet's mantle." All, that is, but the sound of us, traveling ever farther into space on radio waves that don't die.

—*Susan Lumpkin*

by Alex Danoff

Bland Is Better

For some birds, it pays to be plain. According to a study in the July issue of the *Journal of Applied Ecology*, brightly colored birds cannot withstand high levels of radiation as well as birds with drab plumage. For nearly two weeks in 2006, French and U.S. scientists monitored bird populations near Chernobyl, Ukraine. They counted 57 species at 254 locations and found that birds with vibrant red, orange, or yellow feathers were less abundant in highly radiated areas than birds with black, brown, or gray feathers.

All living things use organic substances called antioxidants to neutralize free radicals, atoms that damage DNA and occur naturally and as a byproduct of radiation. Light-colored birds use antioxidants called carotenoids to brighten their feathers, so they have fewer antioxidants left over to stave off free radicals. But birds with darker feathers use melanin, a pigment that does not contain antioxidants, to color their plumage, so they have more antioxidants available. The study shows that while being flashy may be advantageous in mate attraction, it can also have ill effects.

What's in a Name?

Not only are aardvarks (*Orycteropus afer*) listed before any other animal in the dictionary, but their names also have an interesting history. The word aardvark means "earth pig" in Afrikaans and originated in the 1600s with Dutch settlers in South Africa who thought these accomplished burrowers resembled pigs. The genus name *Orycteropus* is Greek for "digger foot," an allusion to the powerful, clawed forefeet aardvarks use to dig burrows and tear into ant and termite colonies. And aardvarks are the only living members of the order Tubulidentata—from the Latin words *tubus*, meaning "pipe" or "tube," and *dent*, meaning "tooth"—a reference to their

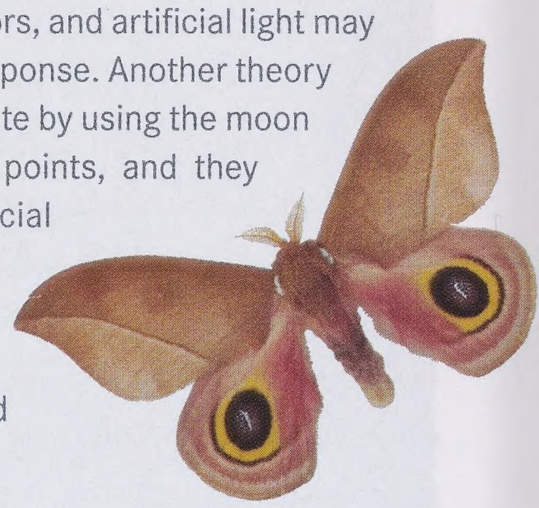
elongated, cone-like mouths filled with small cheek teeth.

Aardvarks are native to sub-Saharan Africa. They are sometimes called "ant bears," although they are not related to bears, or are mistakenly referred to as anteaters, which are New World members of a different order.

The highest-flying bird ever recorded is a Ruppell's griffon (*Gyps rueppellii*), an African vulture that was once spotted at an altitude of roughly 37,000 feet above western Africa.

Why Are Moths Attracted to Light?

Moths tend to flutter around streetlights, lamps, and other sources of artificial light. Scientists don't have a definitive explanation for this intense attraction, a phenomenon called positive phototaxis. One theory is that nocturnal moths, which rest during the day, experience a "morning-light" reaction: They instinctively fly upward toward emerging sunlight at dawn to find a spot concealed from predators, and artificial light may trigger the same response. Another theory is that moths navigate by using the moon and stars as fixed points, and they may mistake artificial lights for these celestial bodies, causing them to spiral inward toward the light source.



In Season

Redosier dogwood (*Cornus sericea*), a deciduous shrub found throughout the northern regions of the United States and as far south as Virginia, stands out during winter. The shrub's tall stems turn from green to bright red in November and December, in stark contrast to barren or snowy forest floors. Redosier dogwood is valuable to wildlife because its small, white berries remain on the plant during the coldest months of winter. When food becomes scarce, birds, rodents, and bears feed on these berries, while rabbits and beavers gnaw on the shrub's bark and twigs.

Fact or Fiction: Virginia Opossums Hang Upside Down

Despite its name, the Virginia opossum (*Didelphis virginiana*) is found throughout North America and is the continent's only marsupial. Although its prehensile tail is handy for maintaining balance and gripping branches as it climbs, it is not strong enough to support the opossum's body weight for more than a few seconds—certainly not long enough to hang upside down. This misconception likely arose from observations of opossums wrapping their tails around tree limbs and briefly dangling while descending from branches. A curious variation of the myth is that the opossums hang from their tails while sleeping, but, like most other mammals, they lie prostrate when snoozing.

Blue tit (*Cyanistes caeruleus*): Ernest A. Janes/Bruce Coleman Inc. Moth (*Automeris* sp.): photos.com. Aardvark: Clem Haagner/Bruce Coleman Inc. Griffon: James Ferrie/iStockphoto.com. Opossum: Jeffery Huber/iStockphoto.com

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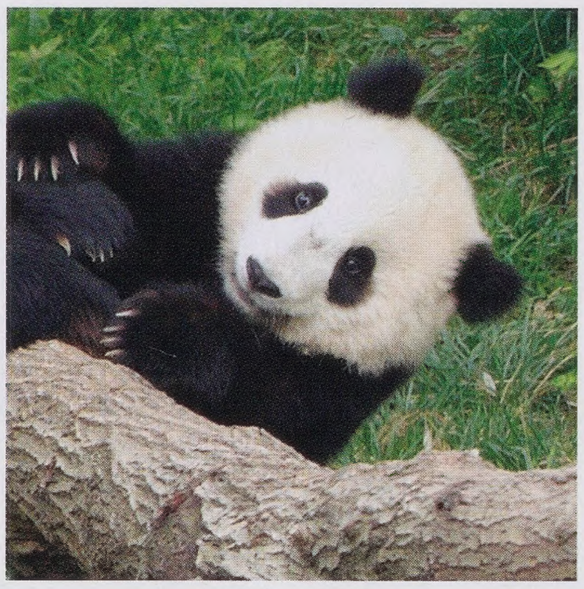

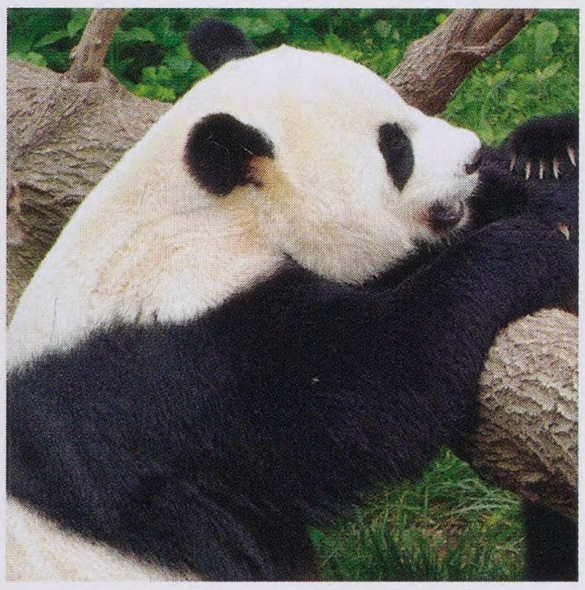

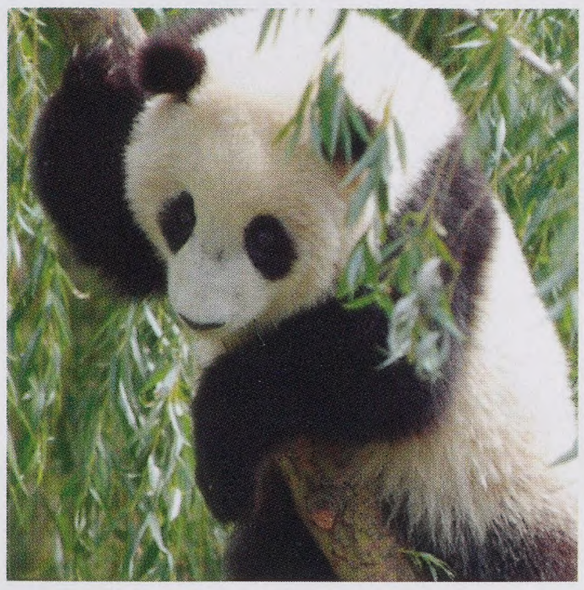

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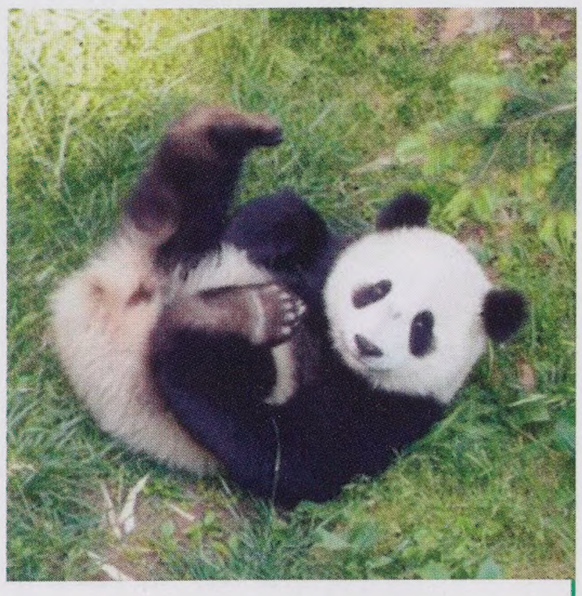

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